Title: METHOD AND APPARATUS FOR DETERMINING DATA TRANSMIT DIVERSITY MODE OF BASE STATION

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Cross Reference to Related Applications

[0001]   This Application claims priority to Taiwan Patent Application No. 091134914 entitled "Method and Apparatus for Determining Data Transmit Diversity Mode of Base Station", filed December 02, 2002.

Field of the Invention

[0002]   The present invention relates to a method and an apparatus for determining data transmission mode of base station in wireless communication system, and more particularly, to a method and an apparatus for a mobile unit determining the data downlink transmit diversity mode of base station.

Background of the Invention

[0003]   In recent years, the spread spectrum communication systems are more and more important in digital cellular and personal communication networks. In particular, direct sequence code division multiple access (DS/CDMA) has been adopted in third generation cellular standard.

[0004]   Improvement of downlink capacity is one of the main challenges for 3G evolution. Transmit diversity provides an attractive avenue for increasing the downlink capacity problem. In order to reduce the interference of downlink transmission to send the better

signal to the base station, the transmit diversity technique uses a plurality of orthogonal antennas to send different modulated signals of one message.

[0005]   The transmit diversity technique can be generally classified as open loop transmit diversity and closed loop transmit diversity. The open loop transmit diversity employs the space time block coding and the full diversity of a plurality of antennas. The distances between antennas should be large enough so that the signal fading received by different antennas can be viewed as independent and the antenna power can be increased. The closed loop transmit diversity mode has tow sub-modes, which use downlink channel measurements and feedback signaling in controlling the phases and/or gain transmit weights in the two transmit antennas.

[0006]   However, the closed loop transmit diversity is typically applied to a low moving speed environment. In a high moving speed environment (above 40 or 50 km/hour), the variation of the signal is too fast. The fast variation causes signal fading and inaccuracy of channel estimating which decays the system efficiency.

Summary of the Invention

[0007]   The present invention improves the system performance by determining the applicability of transmit diversity of a base station in a wireless communication system, e.g. CDMA communications system. By observing the changes of the pilot symbol of the dedicated physical channel and the channel signal of the common pilot channel, the present invention obtains the variation of the channel signal. The present invention further commands the base station to disable the closed loop transmit diversity mode when the variation of the channel signal is too fast or the feedback error rate is too high.

[0008]   The present invention provides a method for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system. First, a first

4API/0241US   2

channel feedback weight having a first feedback phase of the mobile unit during the previous slot is estimated. A second channel feedback weight having a second feedback phase of the mobile unit during the current slot is estimated. The present invention then determines the data transmit diversity mode of the base station according to calculating the first channel feedback weight and the second channel feedback phase.

[0009]   The present invention provides another method for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system by FBI (Feedback Information) error. A tune weight of the mobile unit corresponding to a signal received from the base station during a slot is calculated. The tune weight has a tune phase. A feedback channel weight of the mobile unit during the slot is estimated. The feedback weight has a feedback phase. The present invention then determines the data transmit diversity mode of the base station according to the phase difference between the tune weight and the feedback weight.

[0010]   The present invention also provides an apparatus for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system. The apparatus includes an estimating unit and a determining unit. The estimating unit estimates a first channel feedback weight having a first feedback phase of the mobile unit during the previous slot and a second feedback channel weight having a second feedback phase of the mobile unit during the current slot. The determining unit determines the data transmit diversity mode of the base station according to the first feedback phase and the second feedback phase.

[0011]   The present invention provides another apparatus for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system. The apparatus includes a calculating unit, an estimating unit and a determining unit. The calculating unit calculates a tune weight of the mobile unit corresponding to a signal

received from the base station during a slot. The tune weight has a tune phase. The estimating unit estimates a feedback weight of the mobile unit during the slot. The feedback weight has a feedback phase. The determining unit determines the data transmit diversity mode of the base station according to the tune weight and the feedback weight.

Brief Description of the Drawings

[0012]   Fig. 1 shows a block diagram of transmit diversity closed loop system;

[0013]   Fig. 2 shows a flowchart of a method of calculating feedback weight parameter;

[0014]   Fig. 3 shows a flowchart of the present invention (determination of channel variation) ;

[0015]   Fig. 4 shows a flowchart of the present invention(determination of FBI error) ;

[0016]   Fig. 5 shows an apparatus of the present invention; and

[0017]   Fig. 6 shows another apparatus of the present invention.

Detailed Description of the Invention

[0018]   The present invention provides a method and an apparatus for a mobile unit to determine the data transmit diversity mode of the mobile unit by estimating the downlink data signal from the base station and feeding back a weight signal to the base station.

[0019]   Fig. 1 shows a block diagram of transmit diversity closed loop system. After weighted with a spread/scramble code 102, the signal of dedicated physical channel 101 of the base station 100 is weighted with antenna specific weight factors W_1 and W_2, W_1 and W_2 can be tune weight. The feedback weight factor parameters form weight vectors which are complex valued signals, in general. The base station then adds a first common pilot channel C_1 and a second common pilot channel C_2 to the weighted signals and send those signals to the mobile unit via antenna 1051 and 1053. The channel feedback weight

vectors, W_1 and W_2, which corresponding the phase/power adjustments of the base station 100 are determined by the mobile unit 110. The target is to find a transmit weights that maximize the signal-to noise ratio when the base station transmitting the downlink signal.

[0019.1] The computation of feedback information can be accomplished by solving for weight vector w, that maximizes

$P=w^H H^H H w$

, where $H=[h_1 , h_2]$, and $w=[w_1 , w_2]^T$, The vectors h_1 and h_2 represent the channel impulse responses for the transmission antennas 1051 and 1053. After h_1 and h_2 are estimated, an eigenvalue of the channel autocorrelation matrix $R=H^H H$ is obtained. The optimum transmit weights are the eigenvector $w_f(n)=[w_1 , w_2]$ corresponding to the maximum eigenvalue of the channel autocorrelation matrix $R=H^H H$. The mobile unit 110 then sends the $[w_1 , w_2]$ to the base station 100 for adjusting the phase/power of antennas.

[0020] Fig. 2 shows a flowchart of a method of calculating feedback weight parameter. First, a slot n is initialed 0 in step 201. P is calculated in step 203. The maximum eigenvelue of R and the corresponding eigenvector $w_f(n)=[w_1 , w_2]$ are calculated in step 205. The eigenvector $w_f(n)=[w_1 , w_2]$ is fed back to the base station in step 207. Lastly, n becomes n+1 after waiting for one slot in step 209.

[0021] Since the eigenvector is periodically fed back and is affected by the signal fading delay in high moving speed environment, the closed loop transmit diversity may decrease the system efficiency. The present invention provides a method for determining the data transmit diversity mode of the base station.

Fig. 3 shows a flow chart of the present invention. In closed loop transmit diversity mode, information about the channel is fed back to base station and utilized to provide diversity as well as antenna gain at low mobile velocities under flat fading condition. We can

know that the performance, however, drops at higher velocities. The main reason for this loss

in the performance is the delay associated with the periodic feedback. When the mobile unit

suffers from rapidly fading channel, the performance would degrade in closed loop transmit

diversity mode. Here we provide a method to determine whether mobile unit incur fast

channel variation and its state flow shown in Fig. 3. Before introducing the state flow of

channel variation detection in Fig. 3. There are some important parameters need to define and

explain:

Ph_{diff} : A first predetermined value, Ph_{diff} is threshold defined for comparing with the
phase difference.

P_{th} : A weighting defined for recording the channel variation status.

w_{add1} : A value defined for add with P_{th} upon the decision.

w_{sub1} : A value defined for subtract with P_{th} upon the decision.

$threshold_{diff}$: A second predetermined value, $threshold_{diff}$ is threshold to determine
turn off close loop transmitting diversity mode.

Fig 3 describe steps of this invention, in step 303: estimate the channel impulse from

CPICH every one slot;, step 305: we calculate the channel feedback weights $w_{fb}(n-1)$ of the

previous slot n-1, and in step 307: we estimate the channel feedback weights $w_{fb}(n)$ of the

current slot n; obtain the phase difference of $w_{fb}(n)$ and $w_{fb}(n-1)$ in step 309; If the phase

difference larger than predetermined value Ph_{diff}, we will add P_{th} by w_{add1} and record it.

Otherwise, if the phase difference less than Ph_{diff}, we will subtract P_{th} by w_{sub1} and record it,

in step 311. In step 313, if the P_{th} larger than the predefined threshold $threshold_{diff}$, i.e. the

channel variation is fast. The mobile unit shall send a command for feedback an indication to

base station to ask for stopping CLTD (Close Loop Transmit Diversity) mode, in step 315.

Furthermore, the base station uses the eigenvector fed back from the mobile unit to determine the feedback weight. If the feedback weight in the high moving speed environment is incorrect, the closed loop transmit diversity may decrease the system efficiency. Therefore, the present invention also determines the data transmit diversity mode of the base station by observing the feedback error rate.

In closed loop transmit diversity mode, information about the channel is fed back to base station. But how can we make sure the feedback information is fed back to BS correctly? If there are feedback error, the performance would degrade in closed loop transmit diversity mode. Here we provide a method to determine whether the feedback error rate is high and its state flow shown in Fig. 4. For determining the feedback error, we need the pilot symbols of DPCH for auxiliary. In Fig. 1, we can know that the feedback channel weights would multiply with DPCH. So, we can also estimate the channel weights from pilot symbols of DPCH to see the feedback weights whether fed back BS correctly. If there are no feedback errors, suppose that the phase difference of CPICH and pilot symbol should very similar.

Before introducing the state flow of determination of feedback error, we have to define some important parameters:

$w_{tune}(n)$: The estimation of the tuned diversity weight.

Ph_{error}: A first predetermined value, Ph_{error} is threshold defined for comparing with the feedback error.

FBI_{th}: a weighting for recording the feedback information error

w_{add2}: A value defined for add with FBI_{th} upon the decision.

w_{sub2}: A value defined for subtract with FBI_{th} upon the decision.

$threshold_{error}$: A second predetermined value, $threshold_{error}$ is threshold to determine turn off close loop transmit diversity.

4API/0241US   7

[0022] We would estimate the channel impulse from CPICH every one slot. In Fig. 4, in step 405, we calculate the channel weight from CPICH and pilot symbol of DPCH in current time slot and record it as $w_{tune}(n)$; in step 407, we also estimate the channel feedback weight $w_{fb}(n)$ from pilot symbol of DPCH in current time slot; Then, in step 409, compare the phase difference of $w_{tune}(n)$ and $w_{fb}(n)$ to check the feedback error. We can know that if the phase difference is large, the feedback error must occur. So, we define the following rule to record feedback error. In step 411, if the phase difference larger than Ph_{error}, we will add FBI_{th} by w_{add2} and record it. Otherwise, if the phase difference small than Ph_{error}, we will subtract FBI_{th} by w_{sub2} and record it. In step 413, if the FBI_{th} larger than the predefined threshold $threshold_{error}$, i.e. the feedback error is high. In step 415, the mobile unit shall send a command for feedback an indication to BS to ask for stopping close loop transmit diversity .

[0023] The present invention also provides an apparatus for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system. As shown in Fig. 5, the apparatus 500 includes an estimating unit 501and a determining unit 503. The estimating unit 501estimates the phase of a first channel feedback weight of the mobile unit during the previous slot. The estimating unit 501 further estimates the phase of a second feedback weight of the mobile unit during current slot. The determining unit 503 determines the data transmit diversity mode of the base station according to the phase difference between the first channel feedback weight and the second channel feedback weight.

[0024] The determining unit 503 further includes a comparing unit 5031, a weight unit 5033 and a sending unit 5037. The comparing unit 5031 obtain a phase difference of the

first channel feedback weight and the second channel feedback phase. The weight unit 5033 adds W_{add1} value to P_{th} if the phase difference is greater than a first predetermined value P_{diff}, and subtracts W_{sub1} from P_{th} if the phase difference is less than the first predetermined value P_{diff}. The sending unit 5037 sends a command of disabling a closed loop transmit diversity mode to the base station if the P_{th} is greater than a second predetermined value threshold$_{diff}$.

[0025]   In addition, the present invention provides another apparatus for a mobile unit to determine a data transmit diversity mode of a base station in a wireless communication system. As shown in Fig. 6, the apparatus 600 includes a calculating unit 601, an estimating unit 603 and a determining unit 605. The calculating unit 601 calculates a tune weight of the mobile unit corresponding to a signal received from the base station during current time slot. The tune weight has a tune phase. The tune weight is a difference of a channel signal from a common pilot channel and a pilot symbol of a dedicated physical channel of said base station. The estimating unit 603 estimates a channel feedback weight of the mobile unit during current time slot. The feedback weight has a feedback phase. The determining unit 605 determines the data transmit diversity mode of the base station according to the tune weight and the feedback weight.

[0026]   The determining unit 605 further includes a comparing unit 6051, a weight unit 6053 and a sending unit 6057. The comparing unit 6051 compares the phase difference of the tune weight and the channel feedback weight. The weight unit 6053 adds W_{add2} to FBI_{th} if the phase difference is greater than a first predetermined value Ph_{error}, and subtracts W_{sub2} from the determining value FBI_{th} if the phase difference is less than the first predetermined value Ph_{error}. The sending unit 6057 sends a command of disabling a closed loop transmit diversity mode to the base station if the determining value FBI_{th} is greater than a second predetermined value threshold$_{error}$.

[0027] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the discovered embodiments. The invention is intended to cover various modifications and equivalent arrangement included within the spirit and scope of the appended claims.